

Quality Upgrading, Competition, and Trade Policy: Evidence from the Agri-Food Sector¹

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Abstract. This paper analyzes the extent to which the reduction of import tariffs as a measure of import competition affects the quality upgrading of the food products exported to the EU. This relationship is studied using a ‘distance to the frontier’ model (Aghion et al., 2005) which is based on a non-monotonic relationship between competition and innovation. Quality is inferred from trade data using the Khandelwal (2010) method. The results strongly support the existence of a non-monotonic relationship between competition and quality upgrading, with varieties close to the world frontier being more likely to upgrade quality in response to an increase in import competition. This relationship holds true for both developing and developed countries and is even stronger for countries/products targeted by specific FDI policies. Moreover, there is a strong positive relationship between the diffusion of EU voluntary standard and quality upgrading.

Keywords: Quality Upgrading, Trade policy, Competition, Distance to the frontier, Food Industry

JEL classification: C23, F13, F14, L15, O14, Q17

1. Introduction

Food quality and safety issues have become important topics in the agri-food markets of rich countries in recent decades. This trend has been driven by a variety of factors exacerbated by several food scares that have triggered growing consumer concern about the attributes of foods, the way they are produced, and increasing awareness of the relationship between diet and health (Caswell and Mojduszka, 1996; Grunert, 2005; Bontemps, Boumara-Mechemache and Simioni, 2013). As a consequence, vertical and horizontal quality differentiation of food products has become a necessary condition to satisfy consumer demand (Grunert, 2005). Competition in agri-food markets in this setting switches from price-based to quality-based

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since consumers look for quality and safety differentiated food products (Jouanjean, 2012). Indeed, the development of more heterogeneous, fragmented, and dynamic consumer demand has made price-based competition strategies less attractive and so less successful. Consequently, in recent years strategies have often not only been oriented towards an increase in efficiency or quality control, but also towards generating different systems of increasing product value (Grunert, 2005; Jouanjean, 2012).²

This increase in attention paid to food safety and quality and the growing set of regulations in developed countries has increased the pressure on producers from developing countries to adapt their processes and make goods eligible for export (Jouanjean, 2012). As a result, recent decades have witnessed a growing number of contractual and technology transfers transmitting advanced production capabilities from high to low income economies for the purpose of increasing both productivity and product quality (Swinnen, 2007; Swinnen and Vandeplas, 2007; Goldberg and Pavcnik, 2007).

According to Sutton (2001), product quality is the most important element that allows firms to be successful in international markets, since low productivity can be offset by lower wage rates but firms producing low quality products cannot achieve any sales in global markets, no matter how low the income level. (Swinnen and Vandeplas, 2007). Therefore, improving the quality of exported products represents a necessary condition for economic growth and development especially for developing countries, which often have a comparative advantage in the agri-food sector.

This paper analyzes the extent to which growth in competition, triggered by trade liberalization in the origin country, affects the rate of quality upgrading of the products exported. This relationship is investigated using highly disaggregated import data for the EU-15 in the period 1995-2007 from more than 70 countries and for thousands of food products. Quality has been inferred from trade data using the Berry (1994) nested logit demand system, along the lines recently proposed by Khandelwal (2010). This approach has straightforward intuition: conditional on price, and imports with higher market shares are assigned higher quality.

Our conceptual framework is in the spirit of a growing literature that tests the so called ‘distance to the frontier’ model (see Aghion et al. 2005; 2009; Amable, Demmou and Ledezma, 2010; Bourles, Cette and Cozarenco, 2012; Amiti and Khandelwal, 2013). This class of model suggests that increased competition induces firms (sectors) that are initially close to the technology frontier to innovate more while it reduces the expected rents from innovation for firms (sectors) further away from the frontier. The interplay between these two forces induces a relationship between competition and innovation that is non-monotonic, and conditional on the distance of the firm/product from the (world) technology frontier.

The empirical strategy of Amiti and Khandelwal (2013), who studied the relationship between quality upgrading and competition in the manufacturing sector, is used in the analysis presented in this paper but

² The case of exports of Kenyan horticulture fresh products is a good example of product value increase (Jaffe and Henson, 2004; Jaffe and Masakure, 2005). As a consequence of an increase in competition in the European market and of a progressive change in market conditions, during the 1990s several Kenyan exporters made important investments in order to renew their export basket that led the export value of the horticulture fresh products to increase from \$1000 USD per ton to \$3000 USD per ton (Jaffe and Henson, 2004).

with several differences. Firstly, the destination market is different – the EU-15 instead of the US market – and only a specific sector – the food industry – which was not analyzed by Amiti and Khandelwal (2013). This is a sector where quality attributes play a critical role since they represent a key prerequisite for market access in developed countries. Secondly, data on the FDI sector targeting and Preferential Trade Agreements (PTAs) with the EU is used in this paper in order to test for the heterogeneity of the escape-competition and discouragement effects on different trade policies. Thirdly, the sensitivity of our results to alternative methods of measuring product quality was tested as well as alternative methods of measuring import competition, and the diffusion of the EU voluntary standards is also examined in this paper.

The main results support the prediction of the distance to the frontier model. Firstly, there is strong evidence for a non-monotonic relationship between competition and quality upgrading. Varieties close to the world frontier are more likely to upgrade quality in response to an increase in competition while the opposite effect holds for varieties far from the frontier. Moreover, on average varieties far from the frontier display faster quality upgrading, confirming a clear convergence on quality. Secondly, these results overall hold true for sub-samples of OECD and non-OECD countries, and are stronger for country-sectors that are targets of specific FDI policies and for countries *without* a preferential trade agreement with the EU. Finally, there is also a strong positive relationship between quality upgrading and the diffusion of EU voluntary standards.

This paper deals with two main strands in the international trade literature. Firstly, the recent development of trade models with heterogeneous firms. Indeed, while there is broad evidence in the literature for the pro-competitive effect of trade liberalization (see Melitz and Trefler, 2012, for a recent review), only a few studies have investigated the relationship between competition and quality upgrading, and none of these focus on the food industry. One of the most important contributions to this strand of literature comes from the Melitz (2003) model, where firms, which produce horizontally differentiated varieties under monopolistic competition, can be ranked according to an exogenous attribute, productivity, on which their export status depends. In this model, an increase in competition leads more productive firms to enter the export markets while less-productive firms are driven out of the market. This seminal model has formed the basis of a new wave of theoretical and empirical contributions that explicitly consider heterogeneous quality across firms, allowing firms to produce vertically differentiated products by choosing to input different quality (see Verhoogen, 2008; Baldwin and Harrigan, 2011; Kugler and Verhoogen, 2012; Crozet, Head and Mayer 2012; Fajgelbaum, Grossman and Helpman, 2011; Crinò and Epifani, 2012).³ All of these contributions show that more efficient firms have higher export performance as they use more expensive and better quality inputs to sell higher-quality goods at higher prices.

³ See Linder (1961), Falvey, and Kierzkowski (1987), and Flam and Helpman (1987) for seminal contributions studying the influence of product quality on international trade. Empirical evidence of the link between product quality and trade patterns can be found in Schott (2004) and Hallak (2010). In contrast, firms' level evidence for the food industry can be found in Verhoogen (2008), and Curzi and Olper (2012). The contribution of product quality to economic growth is investigated theoretically by Grossman and Helpman (1991) and empirically by Hummels and Klenow (2005).

The empirical evidence presented in this paper corroborates this line of thinking, adding the important qualification of the role played by the country/firm/variety distance from the technological frontier, improving understanding of the relationship between competition, productivity, and quality upgrading.

Secondly, this paper also deals with the growing and, somewhat contrasting, literature on standards and trade. As is well known, standards could either act as a non-tariff barrier to trade or as catalysts to trade, leading to export gains by modernizing food supply chains through innovation and product upgrading (Swinnen, 2007). Empirically, the trade effect of food standards has largely been studied within the gravity model framework, often highlighting the role of standards as a barrier to trade (e.g., see Olper and Raimondi, 2008; Li and Beghin, 2012). In contrast, little attention has been paid to the direct quantification of the relationship between the diffusion of standards and the rate of export quality upgrading. Although not central to the main aim of the paper, the findings strongly support a positive effect of EU standards on the rate at which exporter countries update the quality of their products. In addition to being new, this result is more in line with the catalyst of trade view of food standards (see Porter and van der Linde, 1995; Jaffee 2005; Maertens and Swinnen, 2009).

Clearly, as suggested in the literature summarized above, to the extent that the quality of exported products matters to the export performance of firms, the findings have interesting and direct implications for trade policies and welfare in countries.

The remainder of the paper is organized as follows: the second section presents various theoretical considerations, summarizing the main intuition of the distance to the frontier model. The third section briefly presents the Khandelwal (2010) method from which the quality of the exported products is inferred, and the data used in the empirical part. Following this, the main results are presented and discussed in the fourth section. Finally, the main conclusions are presented in the last section.

2. Theoretical and empirical considerations

2.1 Theoretical background

How does an increase in competition affect the incentive for a firm to innovate? This relationship is ambiguous according to economic theory. The Schumpeterian branch of endogenous growth theory, which generally focuses on monopoly rents, argues that an increase in market competition reduces the flow of rents and therefore lowers the incentive for innovation and growth (Aghion et al., 2001). On the other hand, several endogenous growth models show that increased competition can encourage innovation (see Aghion and Howitt, 1992). Indeed, incumbents may innovate in order to maintain their market position while potential new entrants aiming to capture the position of the incumbents can surpass them with new and better products (Amable, Demmou and Ledezma, 2010).

More recently, in applying Schumpeterian growth theory, Aghion and Howitt (2005) argue that the relationship between competition and innovation is critically dependent on the position of the incumbents in relationship to the world technology frontier. The entry cost in this model is an exogenous parameter that

determines the level of competition faced by the incumbents (Amiti and Khandelwal, 2013). In this setting, higher competition lowers the cost of entry of potential new entrants, which, in the case of entrance, would replace incumbent firms. The reduction in the cost of entry is associated with an increase in competition in that industry and consequently with firm turnover.⁴

According to this class of model, any policy promoting competition (thereby lowering the entry cost) has an effect on the innovation activity of the incumbents, that depends on their position in relationship to the world technological frontier. Indeed, an increase in competition leads firms (sectors) that are initially close to the technology frontier to innovate more, while it reduces the expected rents from innovation for firms (sectors) further away from the technology frontier. This occurs because incumbent firms close to the frontier know that they can escape and survive the newcomers by intensifying their innovation activities. In contrast, firms far from the frontier have no hope of beating the competition provided by newcomers (Aghion et al., 2009). These two effects are respectively called the *escape-competition* and *discouragement* effects of competition on innovation. These and other authors (e.g., see Acemoglu, Aghion and Zilibotti, 2006; Acemoglu, Gancia and Zilibotti, 2010) argue that the interplay between these two forces induces a relationship between competition and innovation that is non-monotonic, and conditional on the distance of the firm (product) from the world technology frontier. More formally:

$$Y = f(C, D, X)$$

where Y is a firm-sector output performance, C is a measure of market competition, D represents the distance to the technological frontier, while X is a vector of other covariates.

Aghion et al. (2009) found considerable empirical support for this relationship by studying how the entry of firms affects innovation incentives in incumbent firms using a detailed micro data panel for the United Kingdom.⁵ More recently, Amiti and Khandelwal (2013) used similar logic to study the relationship between the rate of growth of quality upgrading (as a measure of innovation) and the reduction of tariffs (as proxy for import competition). They show that the growth of quality upgrading is positively affected by the reduction of tariffs but the magnitude of the effect is indeed conditional on the product distance from the (world) quality frontier.

The application presented in this paper relies on the idea that the distance to the frontier model incorporates all the key features of the competition-innovation relationship. However, other mechanisms have been highlighted in the literature. For example, Amable, Demmou and Ledezma (2010) proposed a simple modification of the distance to the frontier framework showing that the conclusion of an increasingly

⁴ Aghion et al. (2005), in one of the first empirical applications of this type of model, measure product market competition using the Lerner index (or price cost margin). This indicator assumes the value of 1 when price equals marginal cost (perfect competition), while, a value of less than 1 indicates some degree of market power. More recently, Amiti and Khandelwal (2013), in a distance to the frontier model, use disaggregated import tariffs to measure the level of competition within a country.

⁵ Other evidence supporting the interaction between innovation activities and firms/countries distance to the technology frontier can be found in Acemoglu, Aghion and Zilibotti (2006) and Bourlès, Cette and Cozarenco (2012). In contrast, the evidence in support of the distance to the frontier models in Amable, Demmou and Ledezma (2010) and Alder (2010) is mixed, and often not in line with theoretical predictions.

negative impact of regulation on innovation can be reversed when the leader is able to innovate, making it more difficult for the follower to catch-up. The latter extension is coherent with evidence showing that the innovation effort made by leading firms is always more aggressive than that of the followers (e.g. Etro, 2008). Other channels might explain the pro-competitive effect induced by tariff reduction in the liberalizing country.⁶ Among these, some consider that the increased availability of foreign intermediate inputs with higher quality or lower price (Colantone and Crinò, 2014) may trigger technological innovation (Grossman and Helpman, 1991), or have the effect of a greater market size due to economies of scale and selection effects (Helpman and Krugman, 1985; Melitz and Ottaviano, 2008). Moreover, the *firm heterogeneity* literature argues that an increase in trade exposure may improve intra-plant efficiency by stimulating firms to reduce their x-inefficiencies that results in less productive firms leaving the market (Melitz and Ottaviano, 2008).

In what follows, the logic of distance to the frontier model of Aghion and Howitt (2005) is kept as the basic framework. This strategy tests whether or not the findings of Amiti and Khandelwal (2013) hold true in a different market – the EU-15 instead of the US market – and in a specific sector – the food industry – which is only marginally covered by their analysis but where quality attributes represent a fundamental prerequisite in the export success of firms (see Crozet, Head and Mayer 2012; Altomonte, Colantone and Pennings 2010; Curzi and Olper 2012).

2.2 The empirical model

The empirical strategy is in the spirit of the growing literature that tests the distance to the frontier model in which an output variable is regressed on a proxy for competition and its interaction with the distance to the frontier term (e.g. Aghion et al. 2009; Amable, Demmou and Ledezma 2010; Bourles et al. 2012; Amiti and Khandelwal, 2013). In particular, the relationship between competition (here expressed as tariff reduction) and quality upgrading, which represents the country-product output variable, is tested in this paper.⁷ Let D_{icht} be the distance to the frontier of product h (at the CN 8-digit level) exported by country c , at time t to country i , that is, the ratio of its quality to the highest quality within the same product category (see section 3.1 for details). Formally, this strategy is aimed at testing the following empirical model:

$$\Delta \ln \phi_{icht}^F = \alpha_{iht} + \alpha_{ct} + \beta_1 D_{ich,t-5} + \beta_2 \text{tariff}_{chs6,t-5} + \beta_3 (D_{ich,t-5} * \text{tariff}_{chs6,t-5}) + \varepsilon_{icht} \quad (1)$$

⁶ Empirical evidence of the positive effect of trade liberalization on productivity growth can be found in Chen, Imbs and Scott (2009) and Treffer (2004), and in the contributions specifically for the food industry by Ruan and Gopinath (2008) and Olper, Pacca and Curzi. (2013).

⁷ The competitive effect induced by the reduction of tariffs cannot be considered the only determinant of quality upgrading and innovation activities. Indeed, the growth of human capital and R&D activities are more direct measurements of innovation (Nelson and Phelps, 1966; Griffith, Redding and Van Reenen 2004). However, the introduction of this type of variables into the model may be problematic. Firstly, because they cannot represent exogenous factors, and secondly because all of these variables are only available at an aggregated level (e.g. 2-digit level). Besides these considerations, to the extent to which these variables are correlated with the variation in tariffs, and this is not *a priori* obvious, their omission may induce an overestimated tariff effect. However, note that this concern is significantly attenuated by the inclusion of the full set of country and sector (time-variant) fixed effects.

The dependent variable, $\Delta \ln \phi_{icht}^F$, represents the change in the quality of a variety (country c – product h combination) between period t and $t - 5$. All of the explanatory variables are in level for the period $t - 5$ to reduce any potential endogeneity problem. Consequently, quality growth is explained by the lagged distance to the frontier (D_{icht-5}), the lagged import tariff ($tariff_{chs6,t-5}$), and the interaction term of these two variables ($D_{icht-5} * tariff_{chs6,t-5}$).⁸ This interaction term should allow for the non-monotonic relationship stressed by the distance to the frontier models of Aghion et al. (2005; 2009).

An important element to take into account when considering the baseline specification (1) is the presence of both importer country-product-year (α_{iht}) and exporter country-year (α_{ct}) fixed effects. In particular, the α_{iht} fixed effects are of fundamental importance here since the quality measurements are only comparable within the same country-product category or industry. Therefore, the presence of α_{iht} means the variability between product quality estimates that are comparable with each other can be explored, and moreover, within the same importing country. In contrast, the exporter country-year fixed effects control for the potential concern that some country-level shocks (such as technological shocks, changes in relative endowments, or changes in institutions) may affect the competitive environment.

In accordance with Aghion et al. (2009), it is expected that $\beta_2 > 0$ and $\beta_3 < 0$ so the non-linear effect of an increase in competition on the rate of quality upgrading is confirmed. Hence, the positive and negative signs of β_2 and β_3 , respectively, suggest that for varieties close to the world quality frontier – i.e. when the distance to the frontier variable is close to 1 – a fall in tariffs would stimulate quality growth in a variety in the subsequent period. In contrast, for varieties far from the frontier – i.e. when the distance to the frontier variable is close to zero – tougher competition may reduce the rate of quality upgrading due to the discouragement effect. This is due to varieties far from the frontier needing higher tariffs to protect their rents and to promote investment in quality upgrading. Moreover, a value of $\beta_1 < 0$ would suggest that varieties far from the frontier experienced faster quality upgrading during the period considered, that is, there is convergence in quality. Equation (1) is estimated using OLS, considering both the whole sample and different sub-samples of countries and products in order to investigate the possible heterogeneity of the results in specific country conditions such as the level of development, the presence of specific policy affecting FDI inflows, and preferential trade agreements with the EU.

3. Quality estimates, data, and measures

3.1 Quality estimates

Product quality is unobservable. The most common proxy used to measure the quality of exported goods is unit value, defined as nominal value divided by physical volume of a traded product according to which

⁸ The variable “*tariff*” is indexed by *hs6* (instead of *h* as for the variable *D*) since data on tariffs are only available at the HS 6-digit level of disaggregation (instead of the CN 8-digit as for the trade data). See section 3.2 for more details about this.

higher unit value reflects higher quality. However, there are several indications that unit values are an imprecise measure of quality because they also capture other product characteristics unrelated to quality.⁹ Consequently, in order to measure quality, we follow the approach proposed by Khandelwal (2010). This author estimates the quality attached by the US consumers to the imported products. We borrow his method but we implement it in each of the EU-15 countries separately. Regarding this, the potential bias due to specific country preferences towards certain products has been mitigated.

Khandelwal (2010) develops a method to infer product quality using price and quantity information from trade data. This method is based on the nested logit demand function of Berry (1994), and embeds preferences for both horizontal and vertical attributes. Quality is the vertical component of the estimated model and captures the mean valuation that consumers attach to an imported product. According to this method, conditional on price, imports with higher market shares are assigned higher quality. Following Berry (1994), each imported product h belonging to an industry I represents the nest. The demand for an imported variety (product h from country c) at time t depends on the following demand function:

$$\ln(s_{cht}) - \ln(s_{0t}) = \phi_{1,ch} + \phi_{2,t} + \alpha p_{cht} + \sigma \ln(ns_{cht}) + \gamma \ln pop_{ct} + \phi_{3,cht} \quad (2)$$

where s_{0t} is the outside variety, representing the domestic alternative to the imported variety and computed as one minus the import penetration of the industry. Furthermore, s_{cht} represents the overall market share of variety ch and is defined as $s_{cht} = q_{cht}/MKT_t$, where q_{cht} is the imported quantity of this variety and $MKT_t = \sum_{ch \neq 0} q_{cht}/(1 - s_{0t})$ is the industry size. In addition, ns_{cht} is the nest share, that is, the market share of variety ch within product h . $\phi_{1,ch}$ are the variety fixed effects and represent the time invariant component of quality, while the year fixed effects $\phi_{2,t}$ account for the common quality component. Finally, $\phi_{3,cht}$ is a variety-time specific deviation (residual). In contrast, the term pop_{ct} represents the population of country c , and accounts for the so-called hidden varieties.¹⁰ Within this framework, the quality of variety ch at time t , ϕ_{cht} is defined as the sum of the estimated parameters, therefore $quality \equiv \phi_{cht} = \hat{\phi}_{1,ch} + \hat{\phi}_{2,t} + \hat{\phi}_{3,cht}$.¹¹

Two different versions of equation (2) for each NACE 4-digit industry in each EU importing country considered (the EU-15 Member States) were estimated separately. The first version is based on a simple OLS estimator, while the second, using 2SLS, accounts for the potential correlation of the error term, $\phi_{3,cht}$ with both the nest share and the price of the variety. Indeed, both variables are clearly endogenous to market

⁹ First of all, higher unit values could reflect higher quality, but also higher costs (see Aiginger, 1997). Moreover, higher unit values could also be the consequence of higher margins created by market power (Knetter, 1997). See Hallak and Schott (2011) and Khandelwal (2010) for recent evidence about the inadequate ability of export unit values to capture product quality.

¹⁰ According to Khandelwal (2010), a large country size can lead a country to have a greater market share due to the fact that it exports more unobserved or hidden varieties within a product. Consequently, there are population controls for country size. Population data are taken from the World Bank.

¹¹ Note that the terms in equation (2) do not include the importing country subscript i as in equation (1), since equation (2), as in Khandelwal (2010), refers to a generic quality estimation for a given country. In the remainder of this paper, the estimated quality term, ϕ_{iht} includes the subscript i as it refers to any EU importing country i .

share. Following Khandelwal (2010) and especially Colantone and Crinò (2014), the following variables were used as instruments for nest share and price in the 2SLS: the interaction between unit transportation costs and the distance of c from the respective EU destination; the interaction between the oil price and the distance from c ; the number of varieties within each product p ; and the number of varieties exported by each trading partner.^{12 13}

Table 1 summarizes the results of the quality estimates for both OLS and 2SLS regressions. Quality for each importer - NACE 4-digit industry was estimated by carrying out 250 regressions. The median number of observations for the estimations is 4,379 while the average number is 2,427. The pattern of signs matches those of Khandelwal (2010) with negative price elasticity and positive nest share elasticity. Moreover, the median price and nest share elasticity in the estimates for both the OLS and 2SLS is comparable with those in Colantone and Crinò (2014). Similarly, and in line with expectations, when passing from the OLS to 2SLS, a reduction in the estimated elasticity of the price and nest share terms was respectively detected.

As a robustness check, the main findings inferring product quality were also tested by using an alternative and simplified method recently proposed by Khandelwal, Schott, and Wei (2013). The main aspects of this method, which is conceptually similar to that of Khandelwal, are reported in Appendix 1.

With the quality estimates ϕ_{icht} in hand, the distance to the frontier (D_{icht}) can be measured by first taking a monotonic transformation of the quality estimates to ensure that all estimates are non-negative, $\phi_{icht}^F = \exp[\phi_{icht}]$. Then the distance to the frontier of a variety can be defined as the ratio of its transformed quality to the highest quality within each CN 8-digit product: $D_{icht} = \frac{\phi_{icht}^F}{\max_{c \in iht}(\phi_{icht}^F)}$, where the max operator selects the maximum value of ϕ_{icht}^F within a product-year, and $D_{icht} \in (0,1]$. Therefore, D_{icht} for varieties close to the frontier will be close to 1. In contrast, D_{icht} for varieties far from the frontier will be close to 0.

3.2 Data and other variables

Trade data from the EUROSTAT-Comext database was used to infer product quality in each of the EU-15 countries treated as destination markets. Yearly import data in value and in volume for all the EU-15

¹² Oil prices are from Brent. Bilateral distance is the population-weighted number of kilometers between the largest city in each of the two countries provided by CEPII. Since Eurostat does not provide data on unit transportation costs, following Colantone and Crinò (2014), product-level transport costs are computed, starting from variety-specific unit transportation costs for the U.S.A. using data from Feenstra, Romalis and Schott (2002). Following this, these transportation costs are regressed on partner fixed effects in order to remove the influence of the USA. From this regression the average of the residual across all partners within each 6-digit product code is taken.

¹³ As usual in this situation, data is trimmed along different dimensions both before and after the quality estimations. Firstly, varieties with extreme unit values that fall below the 5th or above the 95th percentile of the distribution within industries have been excluded. Secondly, varieties with annual price increases of more than 200 percent or price falls of more than 66 percent have also been excluded. Thirdly, varieties with fewer than 4 observations detected at least twice were excluded. Furthermore, since the quality estimates obtained are noisy, the quality estimates at the 5th and 95th percentiles were excluded too. Finally, any observation with five-year quality growth outside the 1st and the 99th percentiles were trimmed since the dependent variable that will be used in the empirical part is defined as the quality growth over a five-year interval.

countries was used (except for Luxembourg as production data is not available for this country) and from all trading partners in the World with data. We worked at the maximum level of disaggregation (CN 8-digit) over the period 1995-2007. 2007 was chosen as the final year because as a result of the 2008 and 2010 price spikes, extending the analysis to these periods could introduce noise into the quality estimates.

Data on domestic production for the EU-15 importing countries are drawn from the EUROSTAT Prodcom database, which contains yearly information on the value and volume of domestic production. Prodcom collects data for the EU countries from 1995 onwards and is based on an extensive yearly survey of production activities carried out by firms. Quality estimates are based on production volume data at 8-digit level classified according to the Prodcom classification. This classification is directly linked to the NACE 4-digit classification since the first four digits of the Prodcom code identify the 4-digit NACE industry, enabling easy mapping of products into industries. The Prodcom classification is also easily linked to the CN 8-digit classification through appropriate correspondence tables provided by EUROSTAT.

In order to study the level of competition that exporters face in their own country and industry, *ad valorem* tariffs were used for all of the exporting countries with data. This data was collected from WITS (World Bank) at the HS 6-digit level through time. Note that the tariff rate does not need to be aggregated thereby avoiding any bias linked to choice of aggregation method. All tariffs are expressed as *ad valorem* equivalents. For products where there are also specific duties, the world unit values were used to transform them into *ad valorem* equivalents.¹⁴ Tariff data is not available for all of the countries in the sample used in this study. Consequently, the distance to the frontier for each product-year is only defined by considering the set of countries with tariff data.¹⁵

The final database has more than 700,000 observations and contains information on the quality of more than 1,500 CN 8-digit food products exported to the European Union by more than 70 countries, and on their respective import tariffs at the HS 6-digit level. Table 2 reports data on the CN-8 products belonging to each NACE 4-digit industries as well as the level of the respective 4-digit (simple) average tariffs for the exporting countries sampled in the period 1995-2007.

An important innovation in the analysis presented in this paper is how FDI policies affect the link between competition and quality upgrading. Consequently, data on industry-level targeting from the 2005 Census of Investment Promotion Agencies (IPAs), conducted by the World Bank is used.¹⁶ Sector targeting is considered one of the most effective ways of attracting FDI. Harding and Javorcik (2011) recently found empirical evidence that a national IPA targeting a particular sector can attract more than double the FDI inflows. Consequently, as argued by Harding and Javorcik (2012), data on sector targeting is a good proxy for FDI inflows, and moreover, they are less susceptible to the possible simultaneous relationship between FDI and quality upgrading. In fact, FDI can improve the quality of the exported products but they could also

¹⁴ For further details see the documentary research concerning the ‘calculation of *ad valorem* equivalents’ on the WITS web site at <http://wits.worldbank.org/wits/>.

¹⁵ Data for the preceeding year has been included for those countries with no tariff data for a particular year. Also note that countries within the European Union have common tariffs.

¹⁶ Data on direct FDI inflows does not exist at detailed level of disaggregation.

be attracted by those countries-sectors that already produce and export high quality products. This possible endogeneity bias is clearly attenuated by using the IPA data.

The IPA data set covers 105 countries over the period 1984-2000. For the purposes of this paper, the IPA data from 1995 to 2000 has been used, covering about 50 countries in our sample. The data set includes time-varying information on which SITC 4-digit agri-food sectors were targeted by the national IPAs in their investment promotion efforts.¹⁷ One important advantage of using this data is that developing countries are highly represented in the sample, while data on direct FDI inflows are not readily available for those countries at detailed level of disaggregation. This can be used to test whether or not an increase in competition due to a fall in tariffs exerts a heterogeneous effect on the rate of product quality upgrading according to whether or not countries-sectors are targeted as more attractive for FDI inflows, and so where a better business environment is more likely to be found.

Another relevant issue from the point of view of a developing country is to understand the extent to which the recent development of PTAs played a role in affecting the rate of quality upgrading. Recent assessment of the effect of EU PTAs using a gravity model clearly suggests that PTAs have a positive and significant impact on trade flows (see Jean and Bureau, 2012). However, to the best of our knowledge, there is no evidence on their effect on quality upgrading. This relationship was tested by using a PTA dummy following Scoppola, Raimondi and Olper (2013). In particular, the PTA dummy has been built by considering the presence for each year of a PTA with the EU already in force. Consequently, in addition to the GSP preferential schemes, the PTA signed with the ACP, South Africa, the Mediterranean countries, Chile and Mexico, and the Everything but Arms initiative have been included.

Several other data sets and variables were used to check the robustness of the results presented in this paper. Firstly, in order to control the extent to which the properties of the quality estimates are consistent with previous findings, UNIDO data were used to measure factor endowments of countries-sectors and total factor productivity.¹⁸ The UNIDO database provides data on nominal value added at factor cost, capital labor ratio, number of employees, and gross fixed capital formation over the period 1995-2007 for 34 exporting countries and five processed food industries, defined according to the 3-digit ISIC (Revision 3) classification. Moreover, data on the GDP per capita of countries to proxy for the endowment of a country are taken from the World Bank.

The robustness of the main findings was tested using price (unit value) as proxy for product quality. Since FOB (free on board) prices are required for this test, data from the BACI database (CEPII) is used at

¹⁷ Countries in the sample that have one or more sectors targeted as more attractive for the FDI inflows are: Australia, Chile, Greece, Jordan, Pakistan, Sweden and Venezuela. Countries in our sample that do not have any sector targeted as more attractive for the FDI inflows are: Argentina, Bulgaria, Brazil, Canada, Switzerland, China, Costa Rica, Cuba, Cyprus, Czech Republic, Ecuador, Finland, France, Great Britain, Guatemala, Hungary, Iceland, Israel, Italy, Japan, Kenya, Korea, Lithuania, Latvia, Madagascar, Mexico, Malta, Mauritius, Netherlands, Norway, New Zealand, Portugal, Singapore, Slovakia, Togo, Tunisia, Turkey, Taiwan, Uruguay, South Africa.

¹⁸ TFP is estimated from a value-added function which allows for country, industry, and time-specific effects and assumes variable returns to scale (see Harrigan, 1999; Ruan and Gopinath, 2008; Olper, Pacca and Curzi, 2013). Data on gross fixed capital formation are used to calculate capital stock according to the perpetual inventory method (see Hall et al., 1988; Crego et al., 1998). The estimated TFP is then linked to the NACE 4-digit classification through appropriate correspondence tables provided by the United Nations Statistical Division.

HS 6-digit product level. The main advantage of this database is that FOB prices are obtained through a procedure that corrects discrepancies between the import values, which are generally reported CIF (cost, insurance, and freight), and export values, reported FOB. See Gaulier and Zignago (2010) for further details on the BACI database.

Finally, in order to test whether or not the main results hold when the diffusion of EU voluntary standards are controlled for, data on European standards was taken from the European Union Standard database (EUSDB) (see Shepherd 2007). The EUSDB provides data on voluntary standards in force in the European Union from 1995 to 2003. Data was collected from two sources, CE-Norm and Perinorm International, and was mapped according to the standard trade HS 4-digit classification. The EUSDB only includes standards at the Community level, consequently excluding national standards set by individual Member States.¹⁹

4. Results

4.1 A preliminary look at the quality estimates

Before the relationship between competition and quality upgrading were analyzed, whether or not the quality estimates are consistent with expectations were studied. In particular, how the productivity and factor endowment measurements for the countries are correlated with the quality estimates is of interest. Note that it is simply robust correlations and not the causal relationship that is of interest. Indeed, to some extent, this correlation should be tautological because total factor productivity (TFP) rises as a result of innovation, either reducing costs, or, indeed, increasing the quality of the input or the final products (Helpman, 2011).

Columns 1 and 2 of Table 3 show the relationship between product quality and country-sector productivity, measured as both total factor productivity (TFP) and as real value added per employee. In both cases there is robust positive partial correlation between the quality of the exported products and country productivity. These results are consistent with previous research inspired by firm heterogeneity models according to Melitz (2003), which indicates that more productive firms produce and export higher quality products (see Verhoogen, 2008; Crinò and Epifani, 2012; Curzi and Olper, 2012). Columns 3 and 4 of Table 3 show that a positive correlation also exists between the quality of the exported products and two standard measures of factor endowment, that is, the countries-industry capital-labor ratio and GDP per-capita. Consequently, more capital intensive and richer countries export higher quality products, a result that again supports previous findings based on unit values as proxy for quality (e.g. Schott, 2004; Hallak, 2010).

The above correlations corroborate what was expected, giving credence to the properties of the quality estimates presented in this paper. However, the main focus is on the relationship between competition and quality upgrading, an issue addressed in the next section.

4.2 Baseline results

¹⁹ For a technical explanation of the EUSDB data, see Shepherd (2007).

The main results obtained from estimating equation (1) using OLS are presented in this section. In all specifications, the estimated standard errors are clustered within exporting countries, with EU countries being treated as one country because of their common trade policy. Column 1 of Table 4 reports the baseline results from which whether or not the effect of tariffs on quality upgrading is indeed conditional on the distance to the world quality frontier can be tested. The results strongly support this conclusion. Firstly, in line with expectations, a negative coefficient on the lagged distance to the frontier variable suggests that varieties far from the frontier display, on average, a faster rate of quality upgrading, that is to say, there is clear evidence of convergence in quality between varieties.

Secondly, a significant negative coefficient between the interaction between tariffs and the distance to the frontier variable implies that varieties close to the world frontier are more likely to upgrade products in response to an increase of competition (tariffs reduction). In contrast, the significant positive coefficient on the linear tariff implies that tariffs are likely to have the opposite effect for varieties far from the frontier. Quantitatively, the results show that a reduction of tariffs by 10 percentage points induces a decrease in the rate of quality upgrading of 2.1% for varieties far from the world quality frontier and a 2.5% increase for varieties close to the frontier. Consequently, countries/sectors that produce leader varieties to escape the growing competition increase the rate of quality upgrading while laggard countries/sectors do exactly the opposite, reducing the rate of quality upgrading due to the discouragement effect. These results are in line with the predictions of Aghion et al (2005; 2009), and represent a broad confirmation of the findings of Amiti and Khandelwal (2013).

Since countries in the sample vary strongly in terms of level of development, it is important to study the heterogeneity of the escape-competition and discouragement effects according to various characteristics of the different countries. The results of estimating equation (1) are presented in columns 2 and 3 providing the opportunity to have separate coefficients for OECD and non-OECD countries. The non-linear relationship between quality upgrading and competition is statistically significant in both the OECD and non-OECD samples, although in the latter case the estimated coefficient of the (linear) tariffs term is not statistically significant, but jointly the two terms are significant. Quantitatively, the results suggest that a 10 percentage points reduction in tariffs in OECD countries induces a decrease in the rate of quality upgrading of –2.6% for varieties that are far from the frontier and an increase of 1.2% for varieties close to the frontier. The equivalent numbers for non-OECDs are, respectively, –1.3% and 4.8%. Thus, the quality of products of firms/industries close to the frontier in developing countries is particularly sensitive to the level of market competition.

In general, these findings are relatively close to those of Amiti and Khandelwal (2013) for US imports in the manufacturing industry, although they found a larger magnitude of the estimated effects for OECD countries. Therefore, working with only agri-food products instead of other manufacturing products, there is evidence that quality upgrading in developing countries is more sensitive to a change in import competition. This result is interesting *per se* because it suggests that a process of trade liberalization in developing countries can induce potentially large effects on their rate of quality upgrading in food products.

4.3 FDI sector targeting, PTAs, and quality upgrading

FDI inflows are an important element of globalization that often affects the competitive environment, especially in developing countries. There is a large body of literature pointing out that attracting foreign investors can lead to faster economic growth thanks to increasing capital inflows, transfers of new technologies and know-how, and as a consequence, positive productivity spillovers to local firms (Görg and Strobl, 2001; Görg and Greenaway, 2004; Javorcik, 2004; Javorcik and Spatareanu, 2011).²⁰ Moreover, the presence of multinationals in a host country can affect the composition of its exports through two possible channels. Firstly, multinationals can use the host country as a new platform for the production and export of more sophisticated or higher quality goods than those previously exported. Secondly, multinationals can generate a knowledge spillover effect in the same industry of the host country that can then facilitate firms upgrading product quality (Harding and Javorcik, 2012). For the purposes of this paper, an interesting issue is whether or not an increase in the level of competition has a heterogeneous effect on the rate of quality upgrading, which depends on different policies on the attraction of FDI inflows.

Columns 1 and 2 of Table 5 show results obtained by interacting the variables used in specification (1) with a dummy variable that takes the value of 1 if the IPA of a country at time t considered the sector as a priority target for attracting FDI inflows, and zero otherwise. Consequently, separate coefficients are estimated for countries-sectors that are considered a priority by national investment promotion agencies and for those that are not. The results show that the escape-competition and discouragement effects hold for both groups. However, the effect is more pronounced for those countries-sectors considered as a priority target. Generally speaking, these results are in line with the literature on the effects of FDI inflows improving the quality of the products exported by the host countries.²¹ So there is evidence that the entry of multinationals in the economy increases the ability of those countries to upgrade the quality of their production and, consequently, of their export basket (Wang and Wei 2008; Iacovone and Javorcik 2008; Harding and Javorcik, 2012).²²

Next, a second relevant issue, especially from the point of view of the developing countries, is to understand the extent to which the recent development of PTAs has played a role in affecting the rate of

²⁰ However, the FDI spillover effect is conditional on different elements. Using a firm-level panel data set from Lithuania, Javorcik (2004) provides evidence that the productivity spillover is positively linked to the foreign presence in the downstream sectors (backward linkage channel) and with partially and thus not fully owned foreign projects. However, Javorcik (2004) does not find evidence of spillovers due to either the horizontal or the forward linkage channel. Rojas-Romagosa (2006) argued that the spillover effects are conditional on the absorption capacity of the firms and/or the host country. He pointed out that, counter intuitively, the spillover effect is higher for developed countries than for emerging economies and that it also depends on the technological gap (i.e. the lower the technological gap, the larger the spillover).

²¹ Note that FDI might also be thought of as a form of offshoring in which a multinational retailer can contract a local supplier in order to have higher quality production. In this case, part of the rents that stem from the quality upgrading would go to the investing and not the local firm.

²² Wang and Wei (2008) provide evidence that products exported by Chinese foreign-invested firms tend to have systematically higher unit values than other domestic firms, suggesting that they produce higher quality products. Iacovone and Javorcik (2008) reached a similar conclusion when they compared the unit value of the new products introduced by foreign and domestic firms in Mexico, finding that foreign establishments tend to export higher quality products. Finally, using data on IPAs sector targeting, Harding and Javorcik (2012) provide evidence that attracting FDI inflows can boost the ability of a country to upgrade the quality of its export basket.

quality upgrading. The trade preferences of developed countries for developing countries is one of the most important issue in North-South trade during the last half century (Persson, 2012). Trade preferences have been applied with the aim of increasing the export earnings of developing countries as they can charge higher prices and increase export quantity. Moreover, PTAs can also have a positive impact on export product diversification that is often viewed as a key determinant of economic growth (Cadot, Carrère and Strauss-Kahn, 2013). Recent findings on the effect of EU PTAs obtained by using gravity models have also led to investigation of their direct effects on the extensive margin of trade, that is, the number of varieties exported. It clearly emerges from this relatively new but growing literature that PTAs positively affect the extensive margin. However, the effect is heterogeneous across PTAs (Wilhelmsson and Persson, 2012). Interestingly, it appears to be mainly driven by other things than the tariff provision of the PTAs such as service and investment liberalization, regulation of competition, and protection of property rights (Scoppola, Raimondi and Olper, 2013), a result not inconsistent with the effect of IPAs discussed above.

Therefore, Columns 3 and 4 of Table 5 test the relationship between competition and quality upgrading by splitting the sample into countries with and without a PTA with the EU. Results show that the non-monotonic relationship is only confirmed for countries without a PTA. On the other hand, although some non-linearity is apparent from the data, the estimated relationship for countries granting a PTA is not statistically significant. Consequently, there is no evidence that granting preferential access to developing countries in the food sectors, *per se*, contributed to increasing the rate of the quality upgrading of their products, *ceteris paribus*. However, a potential shortcoming of this finding is that the sample only considers manufactured food products and disregards agricultural products. Indeed, the latter often represent most of the exports from less developed countries with PTAs. Furthermore, a possible reason behind the non-PTAs effect on quality upgrading could lie in a type of (reversal) Alchian-Allen effect, that is, the reduction of (specific) duties could induce a reduction (not an increase) in higher quality exported products (see Emlinger and Guimbard, 2013). If present, such an effect would work against the PTA-quality upgrading nexus. This line of reasoning, although potentially interesting, clearly requires more specific analysis and is beyond the scope of the aim of the present paper.

4.4 Robustness checks

In order to verify the robustness of the findings presented in this paper, whether or not the results hold under alternative definitions of the quality frontier, different quality measures, and a different definition of competitiveness was checked.²³ A fundamental test for the robustness of the results is presented in column 1 of Table 6, where the baseline specification (1) is run using alternative methods to those of the estimate of product quality made by Khandelwal (2010). In column 1 a recent method proposed by Khandelwal, Schott,

²³ Firstly, in order to control whether or not the distance to the frontier measurement could be affected by errors due to randomness or outliers of the highest quality variety, the main specification was run excluding the top quality observation for each product, and the top two quality products (and therefore redefining the frontier). Secondly, the robustness of the results was checked by using the alternative quality measurement of the percentile of the quality of a variety within each product-year pair. The main results hold in all these robustness checks. To save space, these results are not shown but are available upon request.

and Wei (2013) is used to infer quality from a CES demand function. This method intuitively assigns higher quality to a variety if, conditional on price, that variety has a higher export quantity. This method is summarized in Appendix 1 and is conceptually similar to that used above in the previous section, but it does not require the use of any instruments. The results shown in column 1 strongly support the previous findings. Moreover, the magnitude of the coefficients is similar to those of the baseline estimate.

The main specification (1) using prices (unit values) as proxy for quality is re-estimated in column 2. Therefore, the dependent variable is computed as the change in (log) prices between the year t and $t - 5$, while the distance to the frontier is defined as the distance of the price of a variety from the maximum price within the same product category.²⁴ The results again support the main findings, even if the magnitudes of the escape-competition and the discouragement effects are smaller in absolute terms than those of the baseline estimate.

A further potential issue arising out of the results concerns EU trade policy. In fact, since EU countries share the same trade policy, there is no variability in the import tariffs between this set of country-products. Consequently, column 3 of Table 6 shows the test of the main specification (1) using import penetration of EU countries rather than the level of tariffs as a proxy for the level of competition faced by firms in the home country.²⁵ This represents a very important test since data on intra-EU trade represents about the 70% of the sample in the baseline estimate. Therefore, the use of a proxy for the level of competition that also has intra-EU country variation, such as the import penetration, allows possible concerns due to the low variability in EU import tariffs to be addressed. Column 3 reports the result of regressing the change in (log) quality of a variety on the (lagged) distance to the frontier, the (lagged) EU country-industry import penetration and its interaction with the (lagged) distance to the frontier. Consistent with expectations, the coefficient on import penetration is negative while that of the interacted term is positive, and both are very significant. Consequently, the findings are robust compared to the use of other indicators of competitiveness.

Finally, one possible concern with the analysis that is not trivial is that the quality upgrading of the products exported to the EU market could not only be affected by a change in the domestic competitive environment due to an increase or decrease in the level of import tariffs, but also by the presence of rigid food standards in the destination (EU) market (see Olper, Curzi and Pacca, 2014). Indeed, studies based on private and, especially, voluntary standards often find a positive effect of standards on the intensity of trade flows, at least when harmonized standards and North-North trade are considered, although there are several exceptions (see Moenious, 2006; Swann, 2010). Equation (1) in column 4 is expanded by including the lagged value of the (log) numbers of standards and its interaction with the distance to the frontier in the

²⁴ Observations that report unit value changes that fall below the 1st or above the 99th percentile have been deleted.

²⁵ Import penetration in each NACE 4-digit industry and year for all the EU countries in the sample was computed using turnover and import data from Eurostat. Import penetration is defined as the ratio of total imports over the sum of imports plus output, minus exports.

specification in order to test whether or not the main results hold good when the diffusion of EU voluntary standards is included.²⁶

Results in column 4 show that the effect of tariffs remains stable and robust even when controlling for the diffusion of EU voluntary standards. Moreover, it is interesting that the estimated effect of standards is positive and significant for the linear term and negative and significant for the interaction term. However, although some non-linearity is detected (the effect decreases with the distance to the frontier), the relationship is positive for both varieties close to and far from the world frontier. Because the previous standards literature has stressed the heterogeneity of the effects of standards (trade) at different levels, the results above do not come as a surprise.²⁷ However, it is stressed that the average positive effect of EU voluntary standards on the rate of exported product quality upgrading is a remarkable result. This finding rather contrasts with a large body of literature based on the gravity model which often highlights the barrier to trade view of food standards (see Li and Beghin, 2012, for a recent survey). In contrast, the result presented in this paper is more in line with the catalyst of trade view of food standards (see Porter and van der Linde, 1995; Jaffee, 2005; Maertens and Swinnen, 2009). This argument was originally put forward by Porter and van der Linde (1995) who argued that stricter environmental standards can lead firms to intensify their innovation activity, and so enhance their competitiveness as they have an absolute advantage over firms in other countries not subject to these regulations.²⁸ This is consistent with idea that international standards can increase total factor productivity by helping firms to climb the technological ladder (through efficiency gains and quality signaling) and thus reduce the productivity gap with firms located in developed countries (see Goedhuys and Sleuwagen, 2013).

One possible explanation of this finding may stem by the fact that standards can play a role in the reduction of the information asymmetry. As a consequence, producers are more willing to invest in quality if the compliance to a standard convinces consumers that their quality is as claimed. Furthermore, note that this result may also be the consequence of the connection between the diffusion of EU standard and FDI as many firms would be likely to invest in developing countries in order to make sure that their products meet quality standards set in the EU.

5. Summary and conclusions

Product quality and safety issues have become central features in both domestic and international markets for food products. The literature increasingly considers the quality of exported goods determines both the

²⁶ Since data on EU food standard vary at the HS 4-digit level, using importer-product (CN-8)-year fixed effects would lead to a singular matrix. Therefore, in order to avoid this problem, imported-product (CN-8) fixed effects were used instead of importer-product (CN-8)-year fixed effects.

²⁷ See Swann (2010) for a review of the relationship between standards and trade.

²⁸ For example, according to Porter and van der Linde (1995), the development of “cleaner” technologies may lead firms to increase their productivity in the use of resources, with the effect of partially (or more than fully) offsetting their compliance costs. As a consequence, by complying with stricter (or imposed earlier) environmental standard, firms

direction of trade and is a key element contributing to economic growth and development. The study presented in this paper empirically investigated the extent to which the wave of trade liberalization during recent decades has affected the rate of quality upgrading in exported food products. A distance to the frontier framework was used (Aghion et al., 2005; 2009), according to which the innovation activities of a firm – such as quality upgrading – are a non-monotonic function of the level of competition and the distance of the firms to the technological frontier. To test this prediction, product quality was inferred using the method of Khandelwal (2010) to consider 1500 CN 8-digit agri-food products imported into the EU-15 by more than 70 exporters.

Strong evidence was found that an increase in the level of competition only leads to faster quality upgrading of products close to the world quality frontier. These results are consistent with the main predictions of the Aghion et al. (2005; 2009) model and they hold true when the sample is split into OECD and non-OECD countries. Interestingly, it was found that in countries-sectors considered as a priority target for FDI inflows, the escape-entry and discouragement effects are much more pronounced. This result is in line with recent findings, showing that FDI inflows can boost the rate of quality upgrading in the host countries.

These results remain stable and robust under different definitions of the quality frontier and using alternative measurements of the level of competition faced in the domestic country. Finally, it was also showed that the non-linear effect of tariffs is not affected by the diffusion of voluntary standards in the EU countries, and that EU standards have a positive overall effect on the rate of product quality upgrading.

These results support the notion that the initial distance to the world quality frontier is an important element that should be taken into account in evaluating the subsequent effect of trade liberalization policies. These findings also suggest that policies oriented to attracting FDI inflows are a viable strategy, particularly for developing countries wishing to climb the quality ladder in order to increase their presence in international markets. Finally, quite independent of the distance to the quality frontier, the overall positive effect of the diffusion of standards on food export quality upgrading is of particular interest.

It clearly emerges from the results of this paper that policies aimed at promoting domestic competition can trigger the quality upgrading of the exported products. As a consequence of such product quality upgrading, countries could export more and see their welfare improve too.

can benefit compared to their competitors in other countries. More recently, Andr , Gonzalez and Porteiro (2009) argue that complying with “green” policies may enhance product quality and, at the same time, increase profits for firms.

Appendix A.1 Quality estimation using the Khandelwal, Schott, and Wei (2013) method

The robustness of the main findings was also tested by estimating product quality using the approach proposed by Khandelwal, Schott, and Wei (2013). This method is conceptually similar to that of Khandelwal (2010), being based on the following straightforward intuition: “*conditional on price, a variety with a higher quantity is assigned higher quality*”.

Using the country-industry specific elasticity of substitution, product quality is inferred by using the residual from the following OLS regression:

$$\ln q_{cht} + \sigma \ln p_{cht} = \alpha_h + \alpha_{ct} + e_{cht} \quad (3)$$

where α_h and α_{ct} respectively account for product and country-year fixed effects and q_{cht} and p_{cht} are respectively the demanded quantity and the price of product h , imported by country c in year t . Therefore, product quality is inferred using the estimated residual from (3) divided by the country-industry specific elasticity of substitution minus one, $\hat{\phi}_{cht} \equiv \hat{e}_{cht}/(\sigma - 1)$.

An OLS regression was used to estimate equation (3) separately for each of the EU 15 importer country and NACE 4-digit industry. Country-industry specific elasticities of substitution are taken from Broda, Greenfield, and Weinstein (2006), and are available at the HS 3-digit level of disaggregation. Consequently, these elasticities are aggregated at the NACE 4-digit level of disaggregation by taking the median value across all the corresponding HS 3-digit products.²⁹

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²⁹ Data was trimmed along two dimensions: the quality estimates at the 1st and 99th percentiles were eliminated and also any observation with five year quality growth outside the 1st and the 99th percentiles.

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Table A.1 Summary statistics on quality estimates

	Mean		Median	
	OLS	2SLS	OLS	2SLS
Price	-0.260	-0.735	-0.231	-0.655
Nest Share	0.877	0.677	0.892	0.775
Observation per estimation	4379	4379	2427	2427
R-squared	0.851		0.852	
Sargan test (p -value)		0.15		0.02
Varieties per estimation	635	635	354	354
Estimation with stat. sig. price coeff.		0.67		
Estimation with stat. sig. nest share coeff.		0.93		
Total estimations		468		
Total observations across all estimations		1,138,022		

Notes: The top panel reports results estimated by running equation (2) separately for each of the NACE 4-digit food industries in the sample. The bottom panel reports statistics that refer to the entire sample. Sargan test was computed to test whether or not the instruments are uncorrelated with the error term.

Table 2. Numbers of products and mean tariffs for the food sectors considered

NACE 4	Short description	#CN8	Mean Tariff
(1)	(2)	(3)	(4)
1511	Production and preserving of meat	142	0.26
1512	Production and preserving of poultry meat	196	0.15
1513	Production of meat and poultry meat products	108	0.18
1520	Production and preserving of fish and fish products	401	0.12
1530	Production and preserving of fruit and vegetables	495	0.18
1540	Manufacture of vegetables and animal oils and fats	144	0.10
1550	Manufacture of dairy products	204	0.39
1560	Manufacture of grain mill products, starches and starch products	178	0.26
1580	Sugar and cocoa	60	0.17
1581	Manufacture of bread; manufacture of fresh pastry goods and cakes	2	0.25
1582	Manufacture of rusks and biscuits	29	0.18
1585	Manufacture of macaroni, noodles and couscous	11	0.18
1586	Processing of tea and coffee	22	0.12
1587	Manufacture of condiments and seasoning	11	0.09
1588	Manufacture of omogenized food preparation and dietetic food	7	0.19
1589	Manufacture of other food products n.e.c.	37	0.12
1590	Production of ethyl alcohol, cider, malt and other non-distilled fermented beverages	18	0.20
1591	Manufacture of distilled potable alcoholic beverages	67	0.11
1593	Manufacture of wine	99	0.10
1596	Manufacture of beer	4	0.11
1598	Production of mineral water and soft drinks	11	0.09

Notes: Table reports information on the NACE 4-digit food industries for which equation (2) was estimated by considering each EU15 country separately. Due to the lack of production data for some importing countries, the following were aggregated: codes 1531, 1532, and 1533 are included in code 1530; codes 1541, 1542, and 1543 are included in code 1540; codes 1551 and 1552 are included in code 1550; codes 1561 and 1562 are included in code 1560; codes 1583 and 1584 are included in code 1580; and finally codes 1592, 1594, and 1595 are included in code 1590. Column 3 reports data on the number of cn8 products belonging to each NACE 4-digit industry. Column 4 reports data on the mean import tariff (1995-2007) in the exporting countries.

Table 3. Product quality and factor endowments of countries

	Ln Quality _{cht}			
	(1)	(2)	(3)	(4)
Ln TFP	0.270*** (0.0854)			
Ln labour productivity		0.134*** (0.0436)		
Ln capital labour ratio			0.105** (0.0516)	
Ln per capita GDP				0.0887*** (0.0241)
Country-Year fixed effects	YES	YES	YES	YES
Importer-Product-Year fixed effects	YES	YES	YES	YES
No. of obs.	536,519	554,785	617,271	1,016,582
R-squared	0.90	0.89	0.89	0.84

Notes: Table shows results of regressing the estimated quality on (log) total factor productivity, (log) value added per employee, (log) capital-labor ratios, and (log) per capita GDP. All regressions include country-year and importer country-product-year fixed effects. Standard errors are clustered by exporting country. Significance levels: * 0.10 **0.05 *** 0.01.

Table 4. Quality, distance to the frontier, and competition: baseline results

Dependent variable: Δ Quality	(1)	(2)	(3)
	ALL	OECD	NON OECD
Lagged distance to the frontier ($t - 5$)	-0.831*** (0.0956)	-0.881*** (0.0357)	-0.551*** (0.0621)
Lagged tariffs ($t - 5$)	0.217*** (0.0776)	0.264*** (0.0913)	0.129 (0.126)
Lagged tariffs * distance to the frontier ($t - 5$)	-0.463** (0.184)	-0.384*** (0.135)	-0.607*** (0.234)
Country-Year fixed effects	YES		YES
Importer-Product-Year fixed effects	YES		YES
No. of obs.	239,332		239,332
R-squared	0.54		0.54

Notes: All regressions include importer country-product (CN-8)-year and exporter country-year fixed effects. Standard errors are clustered by exporting country (with EU countries treated as one country because of its common trade policy). Significance levels: * 0.10 ** 0.05 *** 0.01.

Table 5. FDI sector targeting, PTAs and quality upgrading

Dependent variable: Δ Quality	(1)	(2)	(3)	(4)
	FDI Sector target	No FDI Sector target	PTAs	no-PTAs
Lagged distance to the frontier ($t - 5$)	-0.856*** (0.0826)	-0.785*** (0.219)	-0.756*** (0.110)	-0.826*** (0.101)
Lagged tariffs ($t - 5$)	0.385*** (0.0991)	0.0612 (0.0740)	0.160 (0.0978)	0.223** (0.0916)
Lagged tariffs * distance to the frontier ($t - 5$)	-1.586*** (0.160)	-0.731** (0.321)	-0.130 (0.282)	-0.513** (0.220)
Country-Year fixed effects	YES		YES	
Importer-Product-Year fixed effects	YES		YES	
No. of obs.	70,386		239,332	
R-squared	0.67		0.54	

Notes: All regressions include importer country-product (CN-8)-year and exporter country-year fixed effects. Standard errors are clustered by exporting country (with EU countries treated as one country because of their common trade policy). Significance levels: * 0.10 ** 0.05 *** 0.01.

Table 6. Robustness checks

Dependent variable: Δ Quality	(1) Quality Khandelwal, Schott and Wei (2013)	(2) Unit Values	(3) Import penetration	(4) Controlling for Standards
Lagged distance to the frontier ($t - 5$)	-1.135*** (0.0127)	-0.710*** (0.0237)	-1.021*** (0.0336)	-0.625*** (0.0556)
Lagged tariffs ($t - 5$)	0.147*** (0.0369)	0.106 (0.0660)	-0.0686*** (0.0149)	0.202*** (0.0750)
Lagged tariffs * distance to the frontier ($t - 5$)	-0.314*** (0.0645)	-0.149** (0.0726)	0.115** (0.0423)	-0.547*** (0.145)
Lagged ln standard ($t - 5$)				0.256** (0.116)
Lagged ln standard * distance to the frontier ($t - 5$)				-0.0461*** (0.0158)
Country-Year fixed effects	YES	YES	YES	YES
Importer-Product-Year fixed effects	YES	YES	YES	NO
Imported-Product fixed effects	NO	NO	NO	YES
No. of obs.	197,203	144,389	218,900	239,332
R-squared	0.55	0.54	0.62	0.24

Notes: All regressions, except that in column 4, include importer country-product (CN8) and exporter country-year fixed effects. The regression in column 4 uses importer country-product and country-year fixed effects. Standard errors are clustered by exporting country (with EU countries treated as one country because of their common trade policy). Significance levels: * 0.10 ** 0.05 *** 0.01.